

STATE OF THE CLIMATE IN 2016





Today's Presenters

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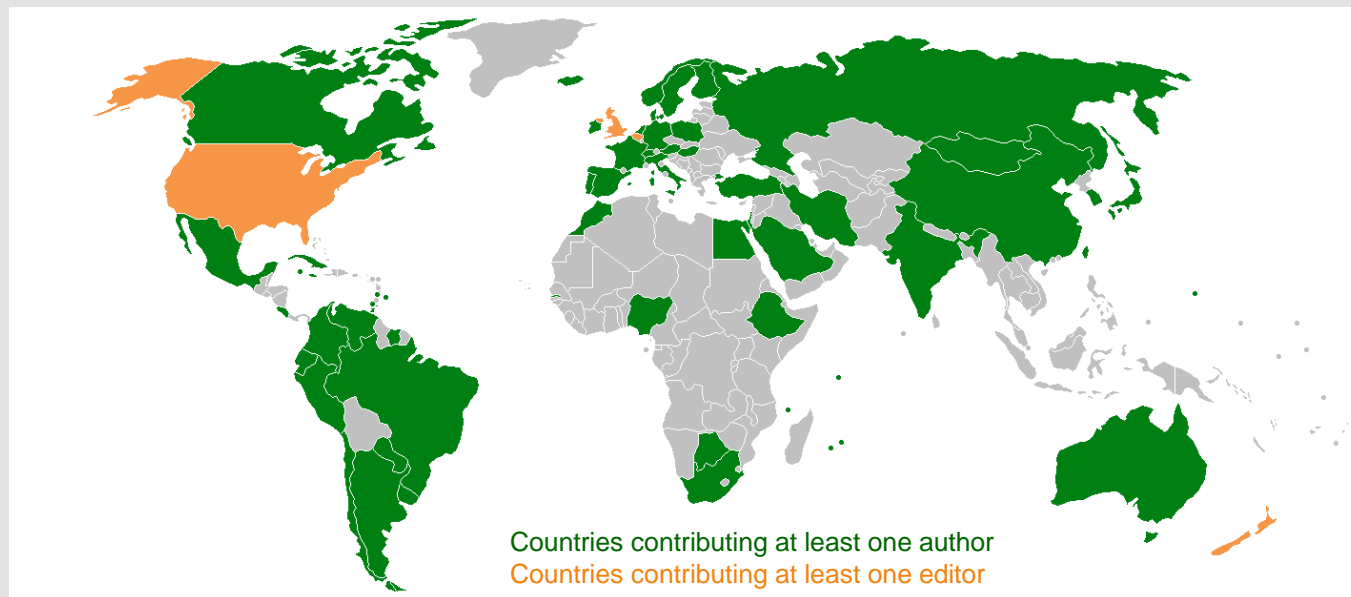
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Report is in its 27th Year of Publication

- Many scientists from many disciplines from around the world fit the pieces of Earth's climate system and its changes together to connect the dots
 - Dozens of essential climate indicators, extreme weather and climate events, historical context
- This report does not pursue “attribution” or contain forecasts, scenarios, or projections



468 authors from 64 countries; 16 editors on 3 continents



Atmosphere



Land

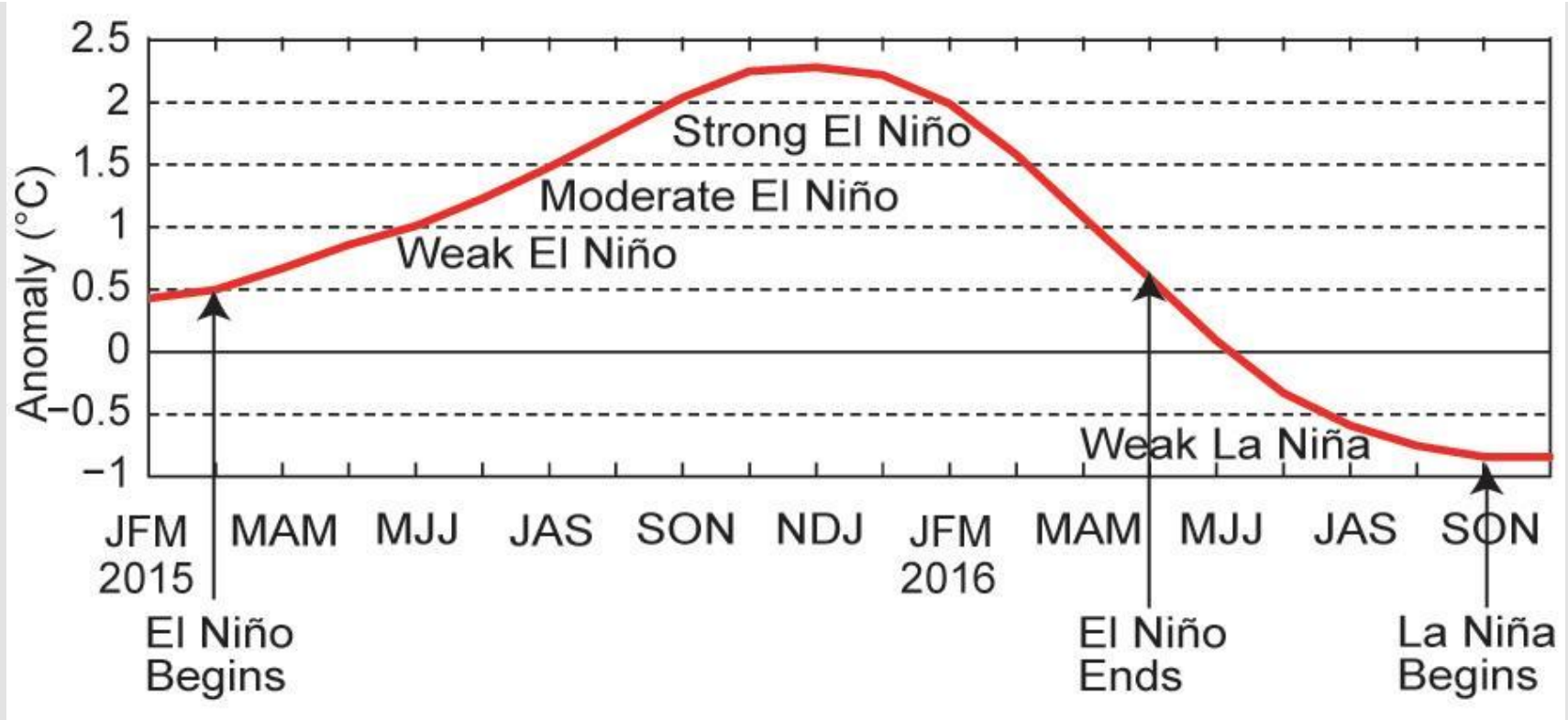


Oceans



Snow and Ice

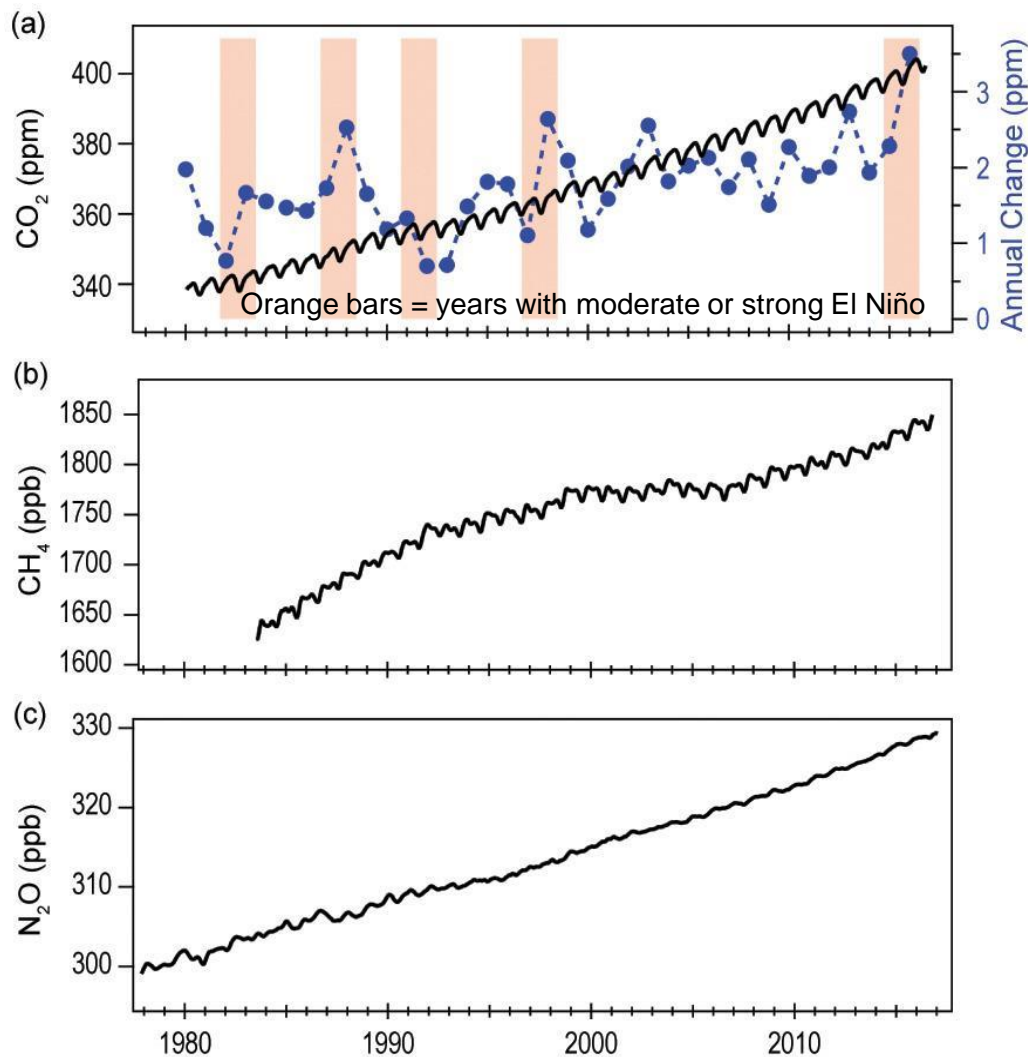
El Niño Conditions Dominate in Early 2016



- Strong El Niño at beginning of 2016
- Transition to weak La Niña by end of the year.

Greenhouse Gases Reach New Record Highs Again

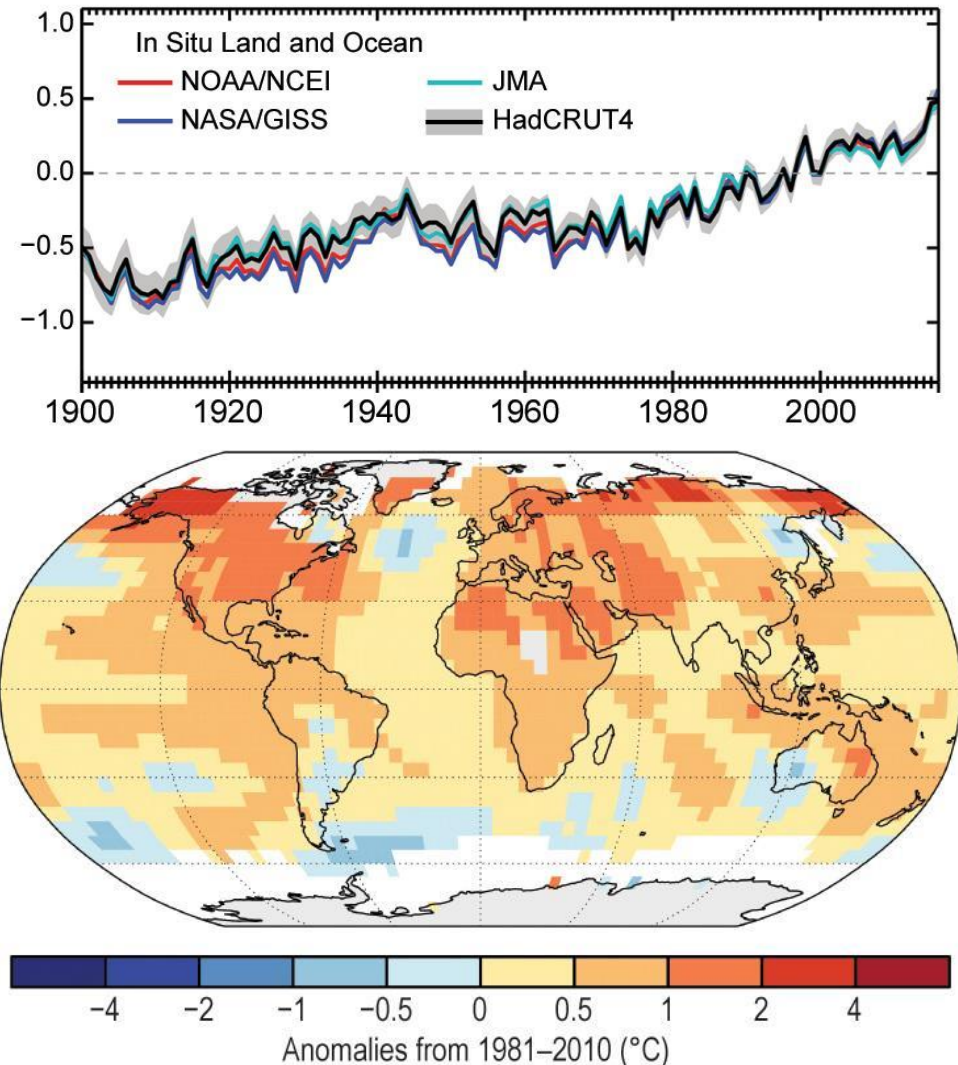
- Global mean carbon dioxide (CO₂) reached 402.9 ppm, a 3.5 ppm increase from 2015. Largest increase on record, possibly influenced by ENSO
- Global mean methane (CH₄) reached 1843.4 ppb, a 9.4 ppb increase since 2015.
- Global mean nitrous oxide (N₂O) reached 328.9 ppb, a 0.8 ppb increase since 2015.



Global Surface Temperature Reaches Record High for 3rd Straight Year

- Four major independent datasets show 2016 was the warmest year since records began in mid-to-late 19th century
- Second year $>1^{\circ}\text{C}$ above pre-industrial levels

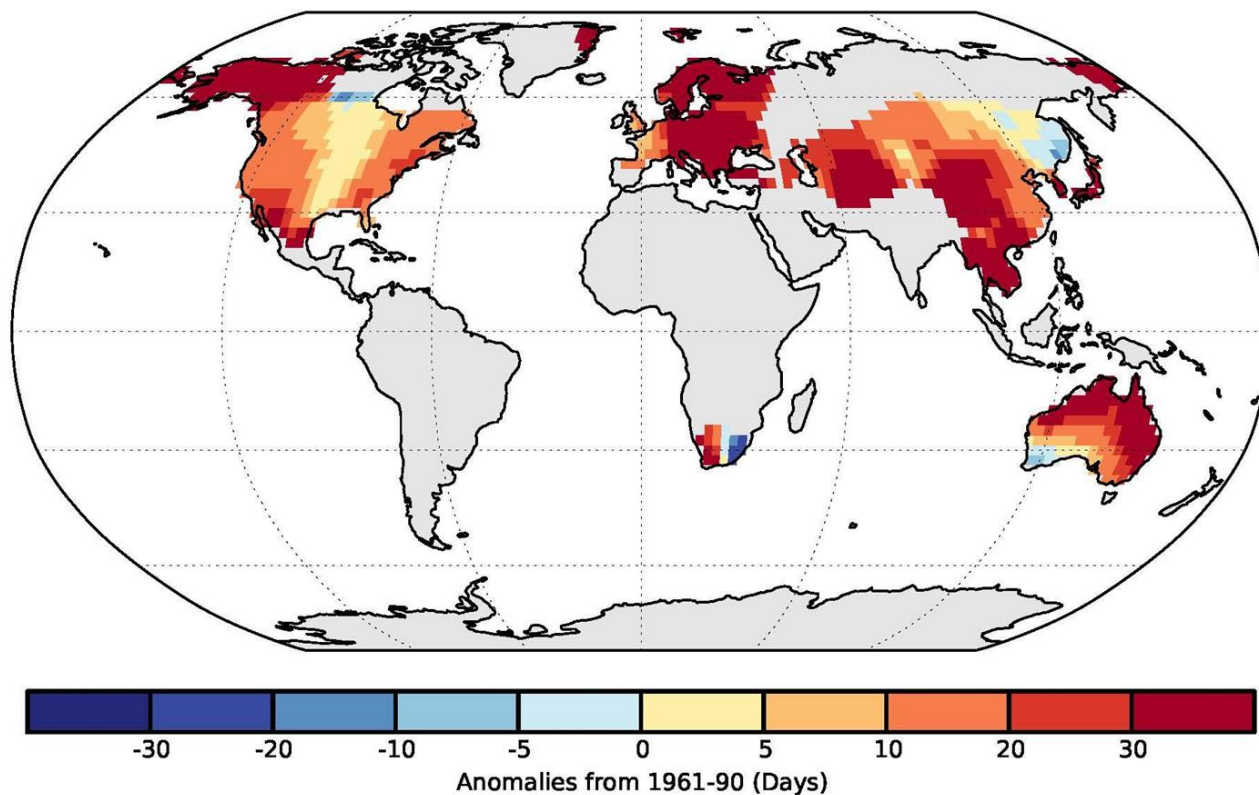
NOAA: Annual Average



Extreme Warm Temperature Events High

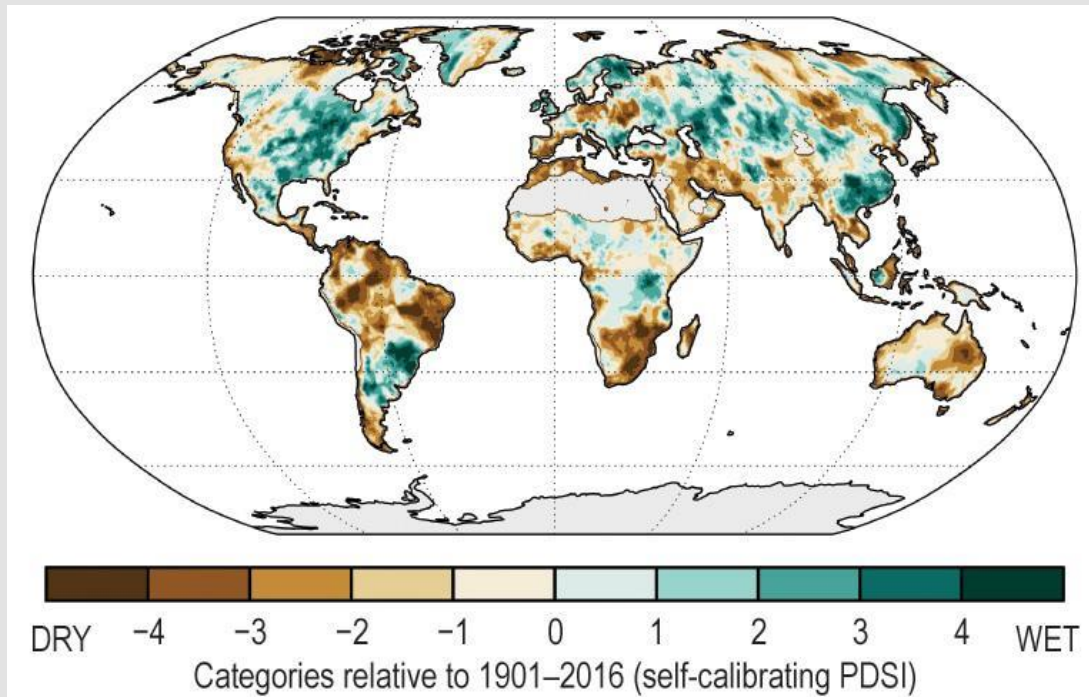
TX90p – Warm Days

- Western North America, Europe, and large parts of Asia and Australia experienced strong warm anomalies throughout much of the year.
- Extreme heat contributed to disastrous wildfire conditions in Fort McMurray, Canada



Drought Affects Nearly 1/3 of Global Land Surfaces

Drought Severity in 2016



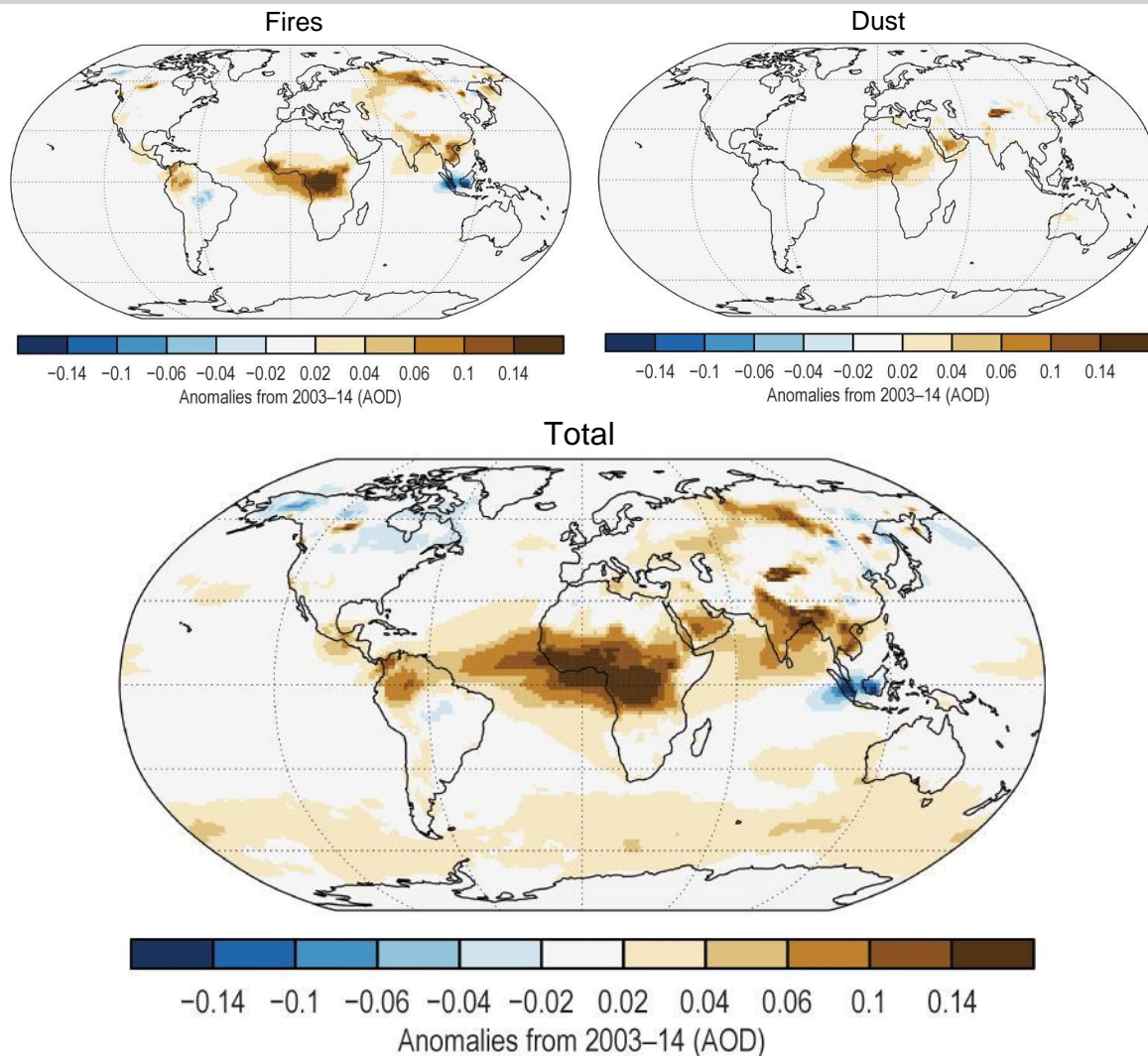
Every month of 2016 had
the following fractions of
land surface experiencing
drought:

>12% severe
>4% extreme

- Extreme drought occurred on every continent
- Dry land-surface conditions also measured in soil moisture, runoff and river discharge

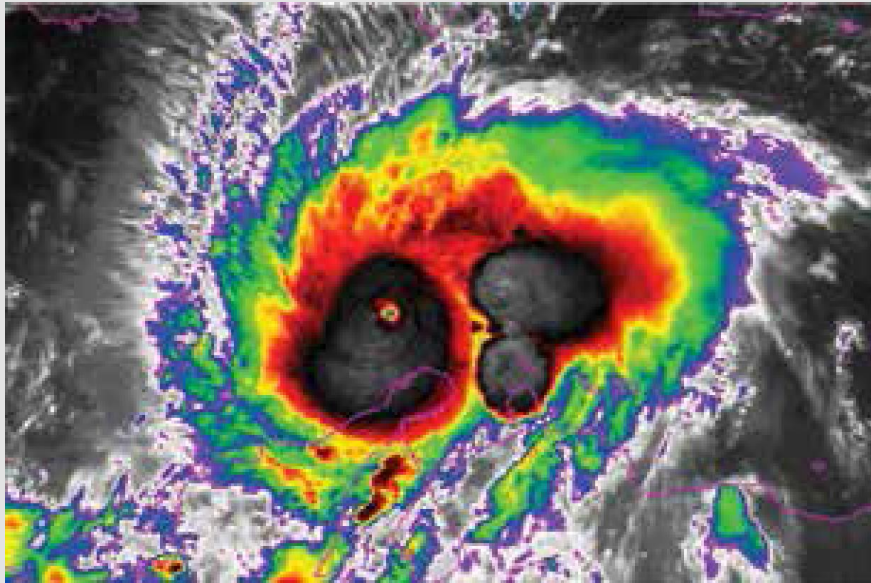
Aerosols show effects from fires and dust

- Aerosols from fires and dust show natural and anthropogenic changes
- Dust from deserts, with active transport over the Atlantic in 2016
- Fort McMurray and Siberian fires as well as equatorial Africa
- Fewer fires in South-East Asia and reduction of deforestation in Amazon
- Anthropogenic emission over Indian subcontinent



Another Active Year for Tropical Cyclones

Globally: 93 tropical cyclones in 2016
(1981-2010 average is 82)



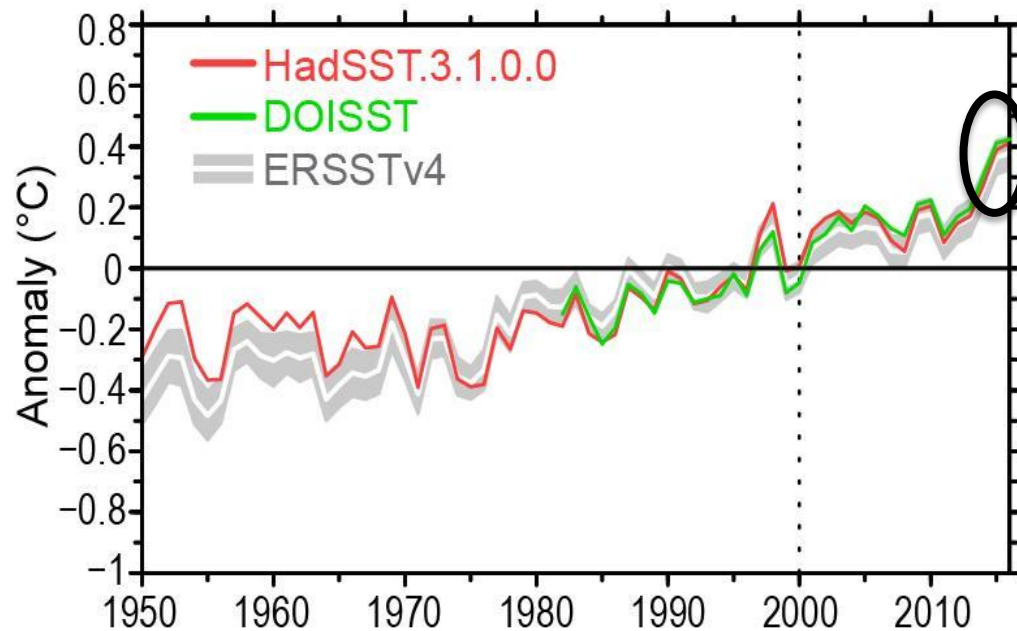
- Category 5 Hurricane Matthew near peak intensity on Oct 1, 2016.
- Storm led to at least 585 fatalities.

- Three basins—the North Atlantic, and eastern and western North Pacific—experienced above-normal activity.
- The Australian basin recorded its least active season since the beginning of the satellite era in 1970.

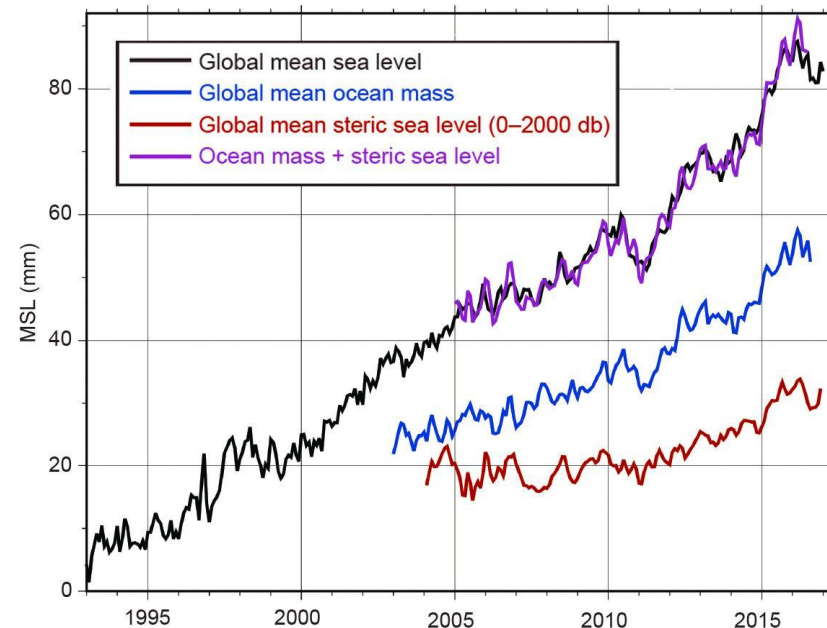
Record High SST & Sea Level in 2016

- Global Sea-Surface Temperature (SST) - record high in 2016
- Global Sea Level - record high in 2016
- Increases from 2015 to 2016 smaller than from 2014 to 2015

Global SST Anomaly (°C)

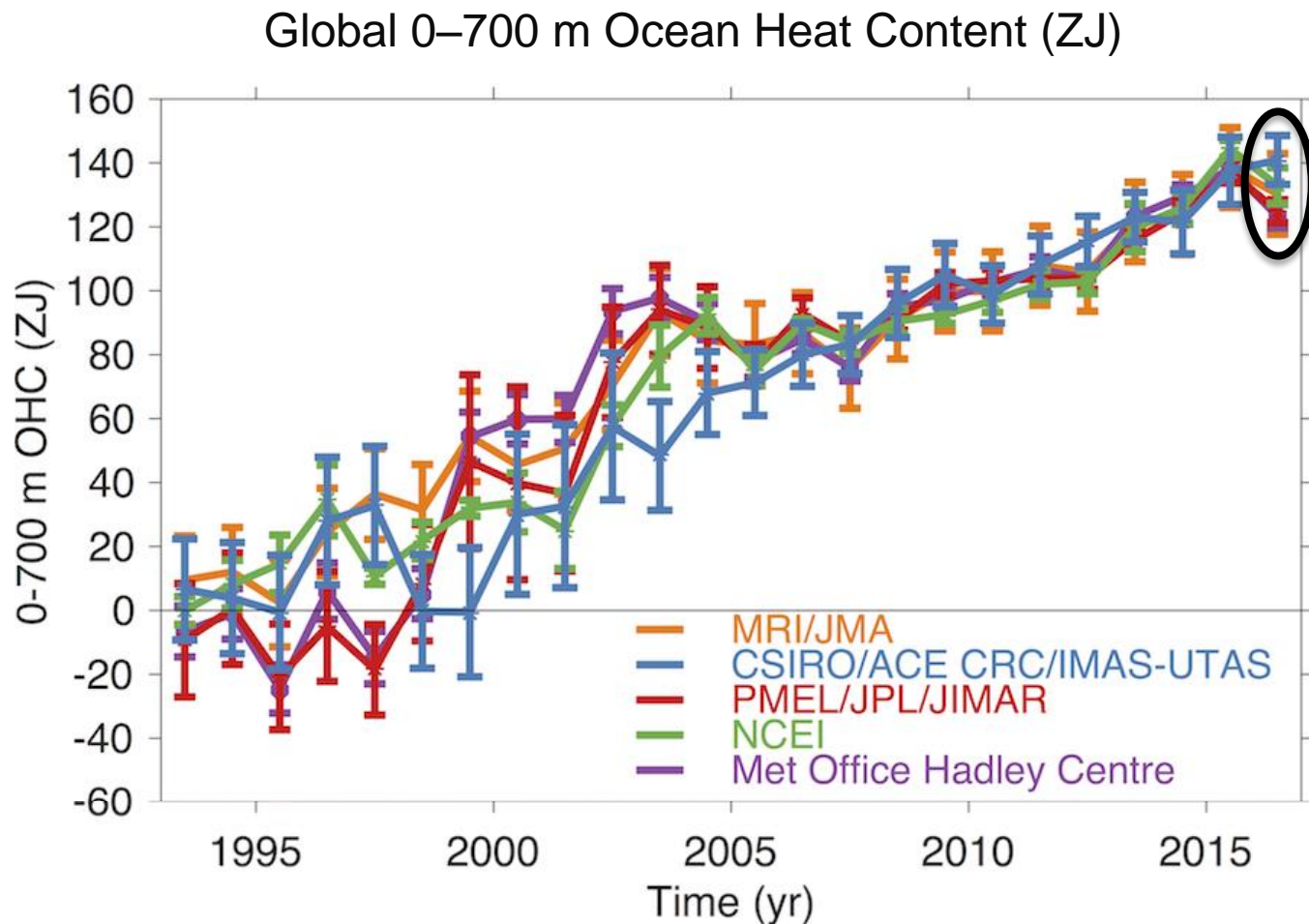


Global Sea Level Anomaly (mm)

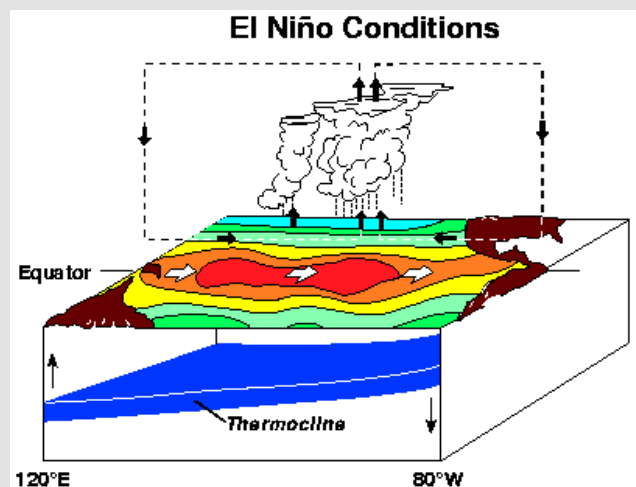
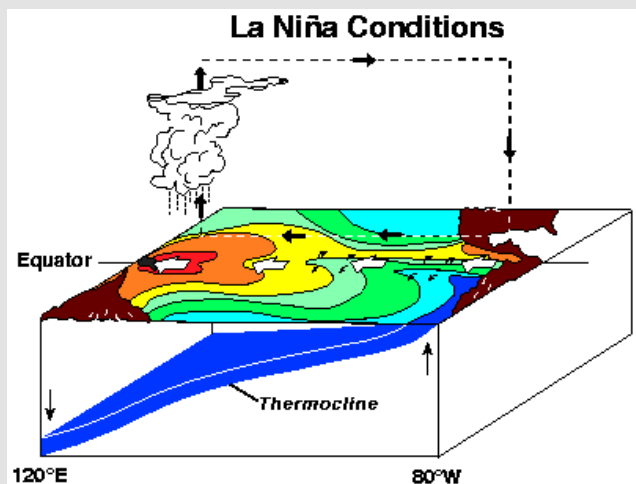


Ocean Heat Content Falls in 2016

- 4 of 5 analyses show Ocean Heat Content fall in 2016
- 2016 still near 2015 record high warmth
- Long-term ocean warming trend robust
- 2016 fall related to 2015/16 El Niño
- El Niño modulates ocean warming & sea level rise rates

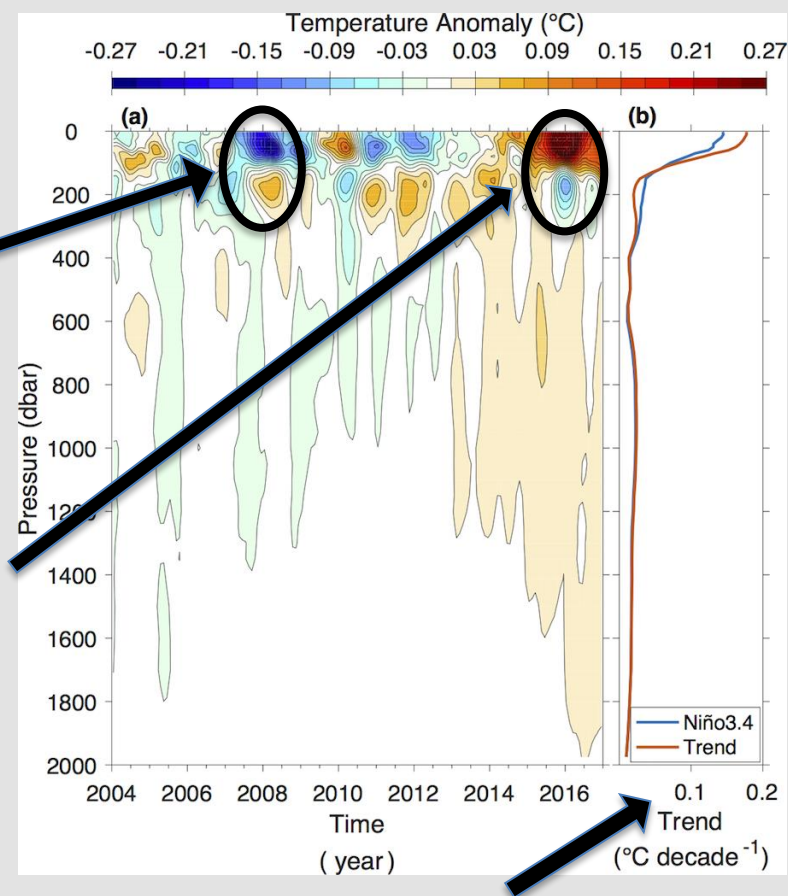


El Niño & La Niña Rearrange Ocean Heat



Global Ocean Temperature Anomalies (°C)

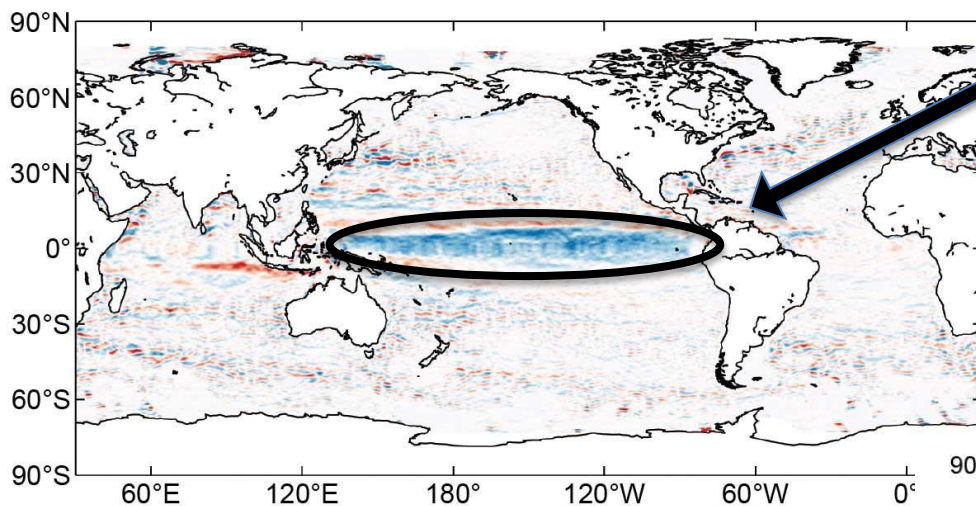
- La Niña conditions bring cold water to the surface (2007/08)
- El Niño conditions spread warm water over the surface (2015/16)



- Robust warming trend to 2000 dbar

El Niño Waned During 2016

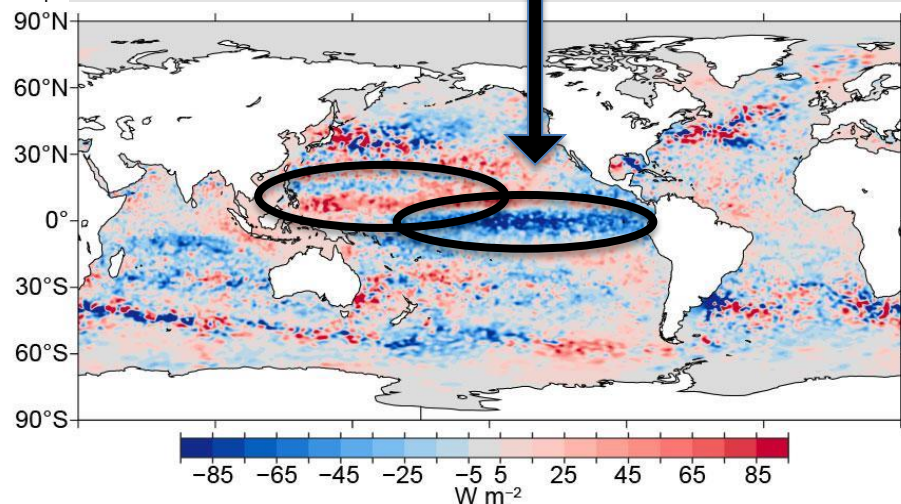
2016 East-West Surface Current Anomalies



*Large El Niño wanes,
east Pacific tropics cool,
seas shed heat, slow rise.
(temporarily)*

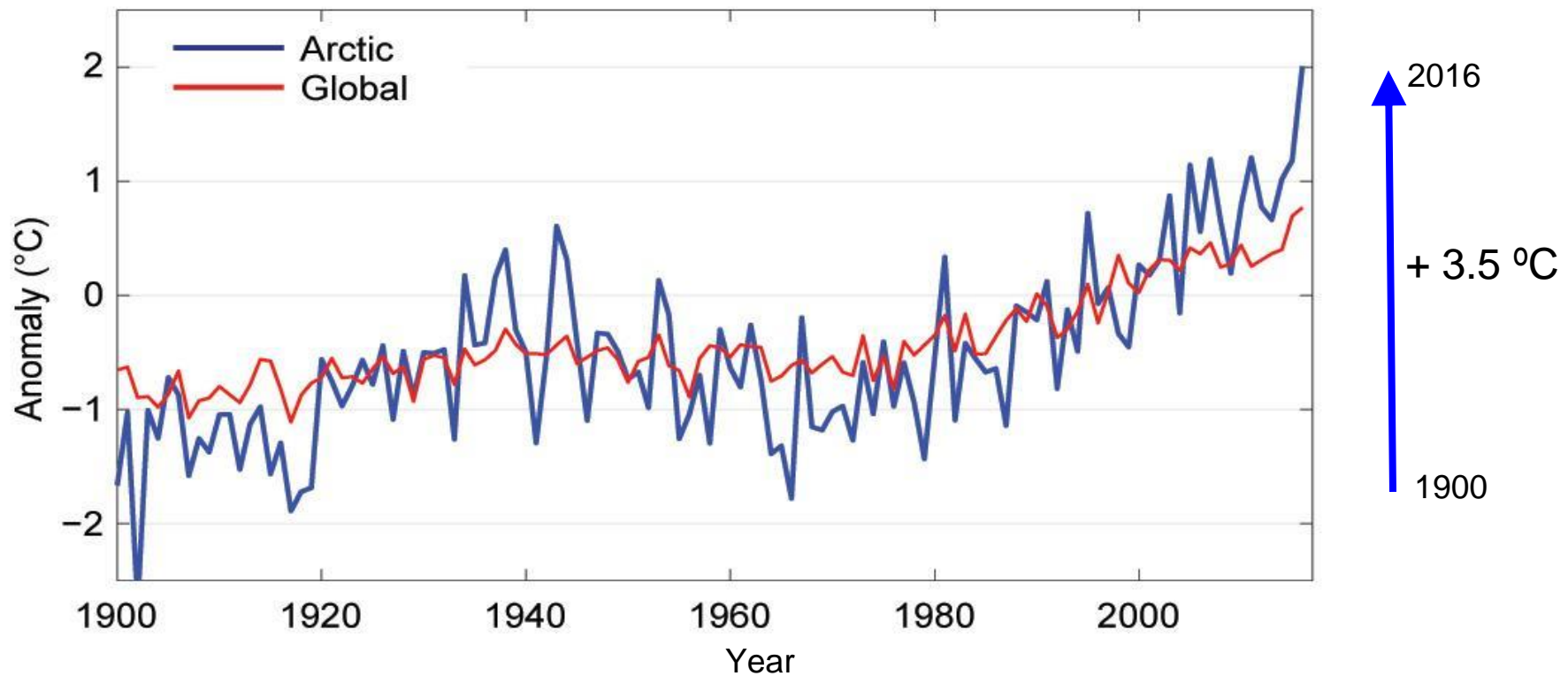
- Strong westward equatorial Pacific surface currents in 2016
- Ocean warmth shifts from East to West (also Equator to North and shallow to deep)

2016 - 2015 0–700 m Ocean Heat Change



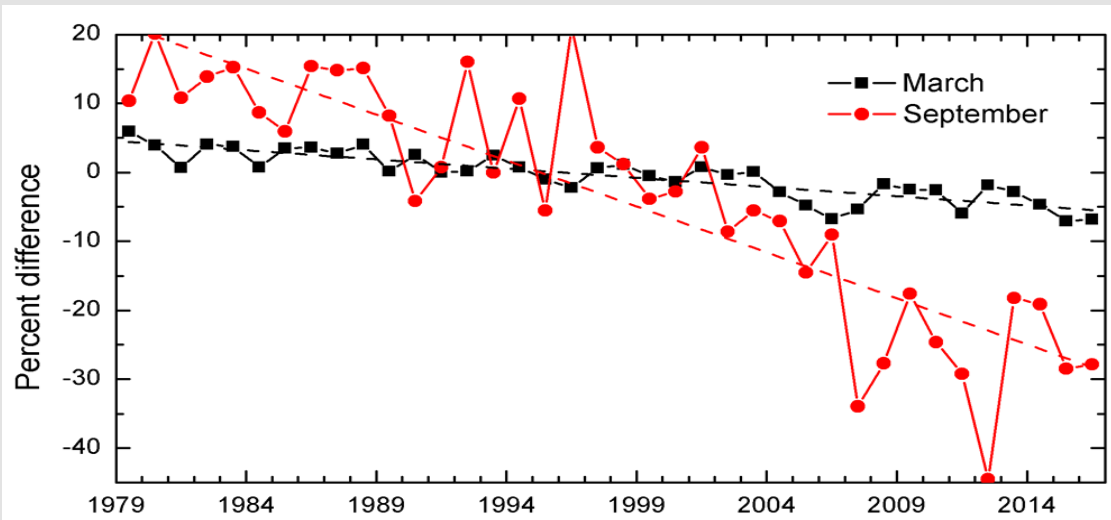
Arctic Temperature “Amplification”

Arctic continues to warm at twice the rate of lower latitudes, driving and responding to change throughout the Arctic system.

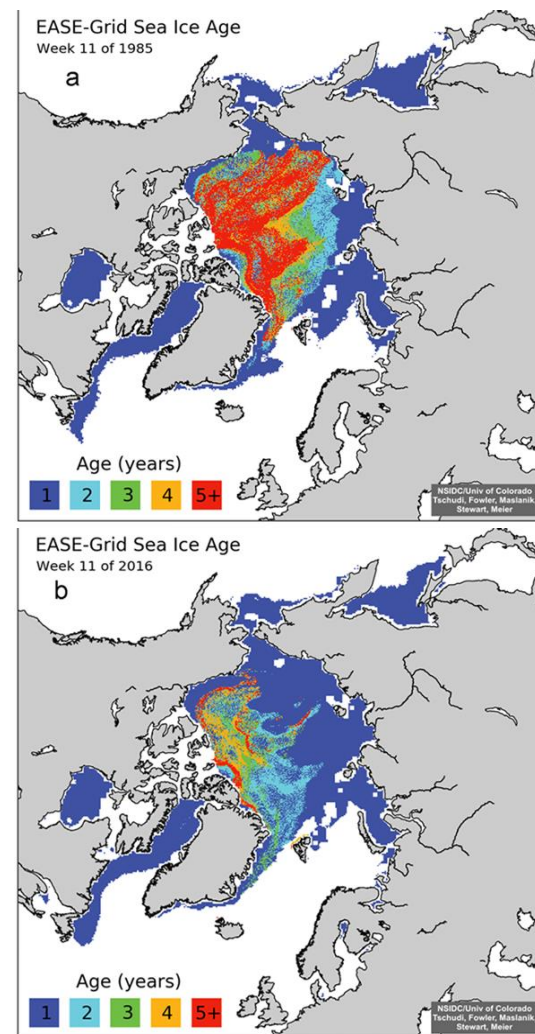


Arctic Sea Ice

Change in Arctic sea ice extent during March and September
Adapted from *State of the Climate in 2015*: Fig. 5.5

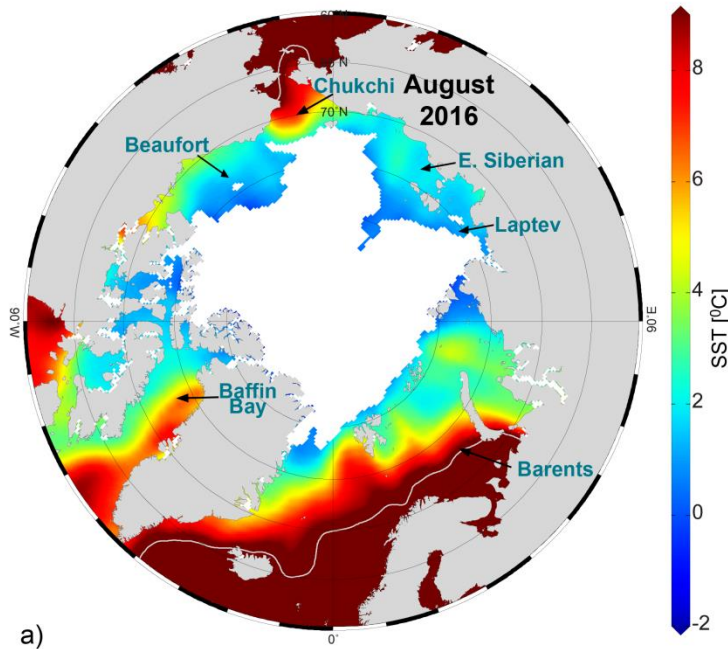


- 24 March 2016: Lowest maximum extent in 37-year satellite record
- 10 lowest minimum extents have occurred in past 10 years
- Trend to younger, thinner cover; more vulnerable to continued extensive melt



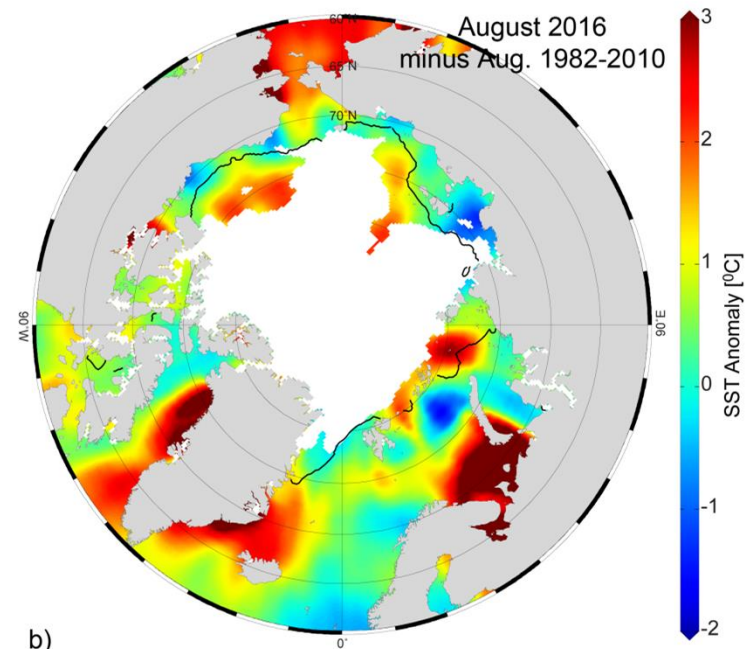
Sea Surface Temperature

Average SST in August 2016



a)

August 2016 minus Aug. 1982-2010 average



b)

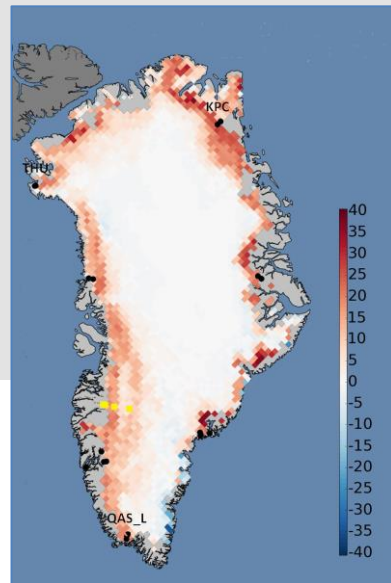
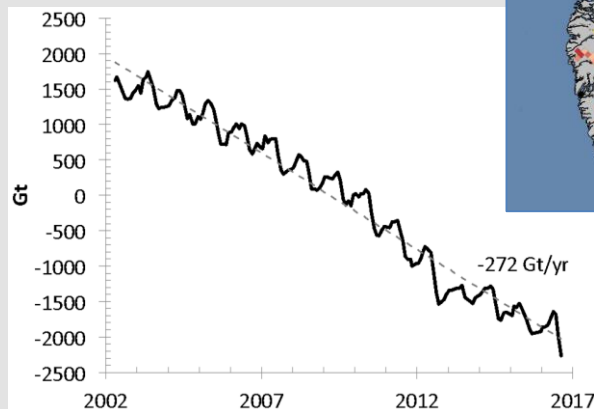
- August 2016: Average sea surface temperature was high in the Chukchi Sea and Baffin Bay ($\sim 7^{\circ}$ to 8°C , or 13° to 14°F) and the Barents Sea (up to 11°C , or 20°F)
- Compared to 1982-2010: Average relatively high in regions that are more recently ice free (e.g. boundary regions and marginal seas near ice edge)

Arctic Land Ice

Warming surface temperatures linked to loss of ice mass

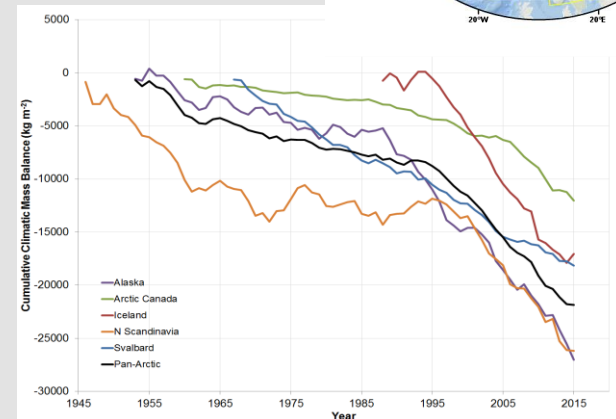
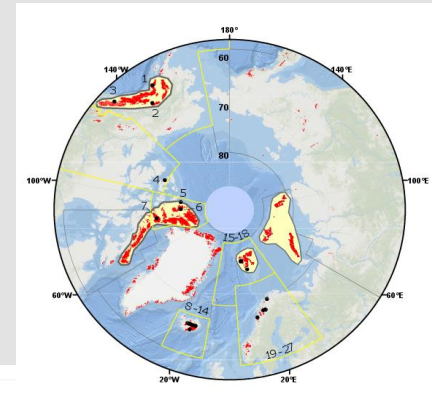
Greenland Ice Sheet

- Onset of surface melt in 2016 ranked 2nd lowest over 37-year record
- Mass of GIS reaches new record low in 2016



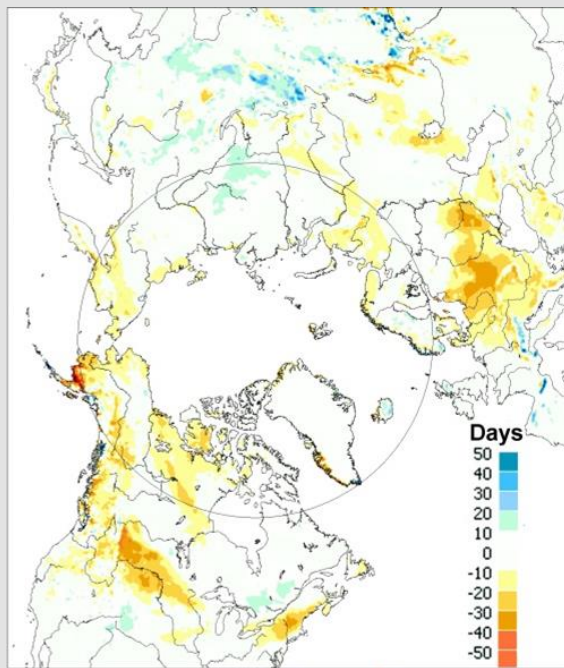
Glaciers and Ice Caps

- Arctic, as a whole, continues negative trend
- Regional variability evident

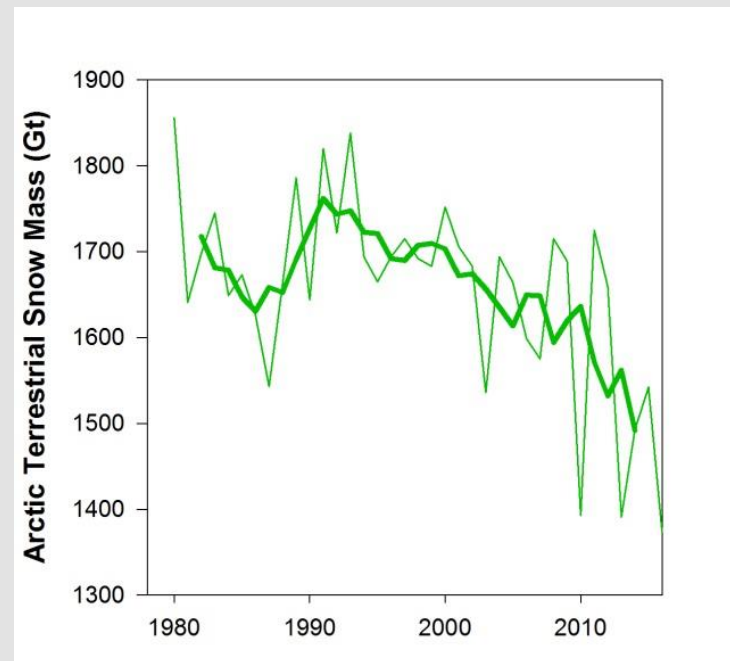


Terrestrial Snow Cover

2016 Spring: Snow cover duration relative to 1998–2010



Arctic terrestrial snow mass
April 1980–2016



- Spring 2016: new record low April and May snow cover reached for North American Arctic
- Increasing evidence that decreasing premelt snow mass (reflective of shallower snow) precondition the snowpacks for earlier and more rapid springtime melt

For More Information



Link to Full Report and Today's Presentation:

<http://www.ncdc.noaa.gov/bams>

Report Highlights:

<https://www.climate.gov/sotc2016>

NOAA's National Centers for Environmental Information:

www.ncei.noaa.gov

NOAA's Pacific Marine Environmental Laboratory:

www.pmel.noaa.gov

NOAA's Office of Oceanic and Atmospheric Research

www.research.noaa.gov

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<http://www.metoffice.gov.uk/>

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